

Preliminary

## Mechanism and Clarification of Electrical Conduction through Wood Charcoal\*<sup>1</sup>

Koei NISHIMIYA\*<sup>2</sup>, Toshimitsu HATA\*<sup>2</sup>  
and Shigehisa ISHIHARA\*<sup>2</sup>

(Received May 31, 1995)

*Keywords* : wood charcoal, carbonization, electric conductivity, chemical structure

### Introduction

Generally speaking, wood biomass pass the several stages of substance conversion when carbonized at various temperatures<sup>1)</sup>. Both physical and chemical properties of wood charcoal are strongly influenced by the carbonization temperature. Electric properties of wood charcoal are also drastically changed in carbonization process. However, the relationship between chemical structures and electrical properties of wood charcoal has been discussed in few works.

In this study, the substance conversion mechanism in the heating process of wood was analyzed using elemental analysis, laser flash method to measure the thermal constants, FT-IR, electron spectroscopy for chemical analysis (ESCA) and X-ray diffraction method, in order to follow the chemical structural change of wood charcoal. From these results, it was discussed to point out the chemical structures.

### Materials and Methods

Wood meal of Sugi (*Cryptomeria japonica* D. Don) and cellulose powder was dried at 105°C for 24 hrs, and then carbonized in electric furnaces at target temperatures. The temperature increased at the rate of 4°C/min, and then kept constant for 1–3 hr after reaching the desired temperature. The charcoal was taken out of the furnaces after natural cooling.

Some charcoal added along with PF resin was formed by hot pressing to measure the thermal constants and electric resistivity and to be analyze with ESCA. The rest was analyzed in the form of powder by elemental analysis, FT-IR, ESCA, etc.

\*<sup>1</sup> This report was presented at the 45th annual meeting of the Japan Wood Research Society at Tokyo, April, 1995.

\*<sup>2</sup> Laboratory of Wood Composite.

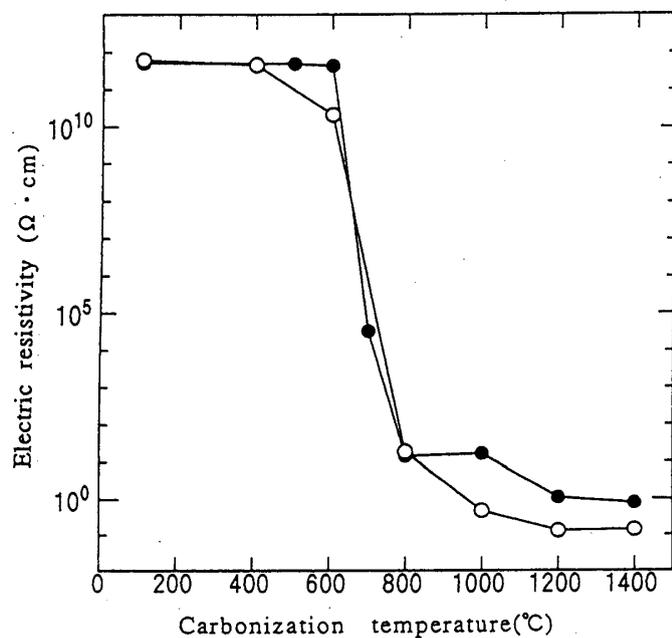


Fig. 1. Relationship between carbonization temperature and electric resistivity.  
Legend: ●: sugi, ○: cellulose.

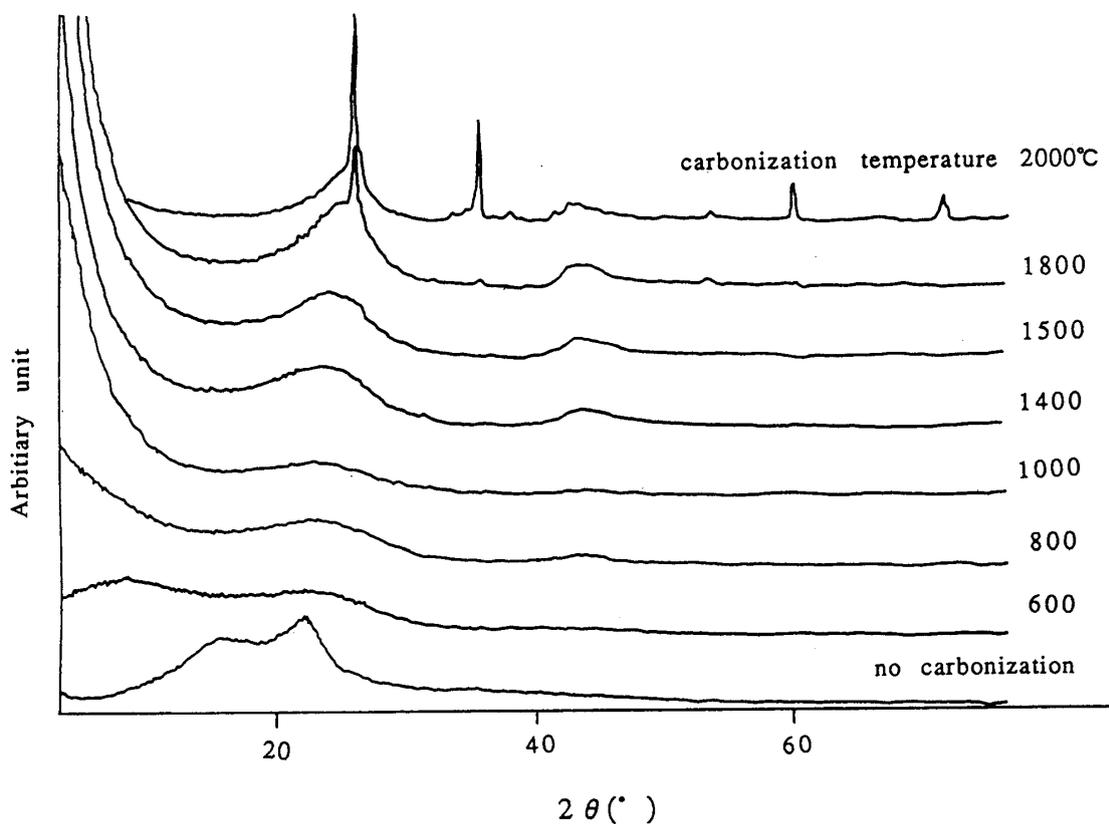


Fig. 2. X-ray diffractograms of wood charcoals carbonized at various temperature from sugi species.  
Note: diffraction conditions; X-ray: Cu-K $\alpha$  (80 mA-50 kV), slit: 1/2°-0.3 mm-1/2°, sampling speed: 4°/min.

## Results and Discussion

Figure 1 shows that the electric resistivity drastically decreased at the temperature from 600°C to 800°C. Wood charcoal has electric conductivity when carbonized above 800°C. The elemental analysis results revealed that the carbon contents increased with the increase of temperature. The experimental formula of the charcoal carbonized at 800°C was found to be  $C_6H_{1.023}O_{0.377}$ , that is, there are about six oxygen atoms per 100 carbon ones in the charcoal. From Krevelen diagram<sup>2)</sup>, the carbonization was proceeded by dehydrogenation below 400°C, decarbonylation or decarboxylation between 400°C and 600°C, and dehydration above 600°C.

It was reflected from FT-IR spectrums that the absorptions of hydroxy groups decreased with increasing temperature, and those of double-bonds and aromatic rings appeared. In the case of cellulose, carbonyl group existed in the charcoal heated at 300°C. However, the absorbance decreased at the carbonized temperature over 600°C. This result was in accordance with the carbonization mechanism which can be analogized from the Krevelen diagram. The results of ESCA also supported this analogy.

In Figure 2, no definite reflection was detected from X-ray diffraction diagrams at the carbonization temperatures between 600°C and 800°C. It was found that no graphitization occurred in the range of this temperature. In other words, no graphitization contributed to the electric conductivity of the charcoal. On the other hand, diffractions of graphite were found above 1800°C. This shows that the new substance transition stage was appeared over this temperature.

From these results, wood charcoal is expected to acquire electric conductivity with the existence of  $\pi$ -electron system originating from the conjugated double bonds. Some of the oxygen atoms are considered to play an important role in electric conductivity.

## References

- 1) S. ISHIHARA: *Wood Mic*, **10**, 33–37 (1994).
- 2) D.W. VAN KREVELEN: "Coal", Elsevier, Amsterdam, 111–126 (1961).